

AMENDMENTS TO THE SPECIFICATION

Page 1, please delete paragraph [0003] and substitute therefor the following:

In these sorts of applications, the arc length of the lamp is required to be as short as possible in order to approximate it to a point source. However, if the arc length is shortened, an arc generation point on an electrode gets unstable depending on the temperature or surface condition of the electrode, so that the phenomenon that the arc origin point jumps to other points is easy to occur. When this sort of phenomenon occurs, visible flicker is perceived in the light output of the lamp, and in case that the lamp is utilized as a light source for a projector, problems are raised, such as difficulty in seeing a screen image due to brightness fluctuation or luminance reduction on plane of projection (screen), or the like.

Page 2, please delete paragraph [0004] and substitute therefor the following:

By the way, when lamp voltage across ~~[[a]]~~ an HID lamp is high, its lamp current decreases and the temperature of electrodes and within a bulb of the lamp decreases, and therefore active chemical characteristics within the bulb are suppressed. When such phenomenon occurs in a metal halide lamp, its halogen cycle does not get active. Usually, a protrusion is formed on the surface of the electrode, and the protrusion serves as an arc origin so that the arc origin is stabilized, but the protrusion is ~~hard~~ difficult to be formed on the surface of the electrode in a condition that the active chemical characteristics within the bulb are suppressed, as described above. On account of this, the arc origin is not fixed, and the phenomenon that the arc origin moves is easy to occur. Also, if a protrusion is not formed on the surface of the electrode and the arc origin does not stabilize, the ~~whole~~ entire electrode suffers damage by the arc, resulting in early electrode degradation.

Page 2, please delete paragraph [0005] and substitute therefor the following:

Incidentally, a technology for reducing flicker of a discharge lamp is suggested in, for example, Japanese Patent National Publication number 2002-532866. In this technology, the shape of a lamp current through the lamp is modified in accordance with detection of flicker generation.

Pages 2 and 3, please delete paragraph [0007] and substitute therefor the following:

According to the technologies described in the Patent Application Publication number 2002-352982 and the Patent National Publication number 2002-532866, electrode wear is controlled. The latter especially directs its attention to reduction of flicker, but there is a need to superpose a pulse-shaped current in order to modify the shape of the lamp current through the lamp, so that a comparatively ~~complicate~~ complicated control is required.

Page 3, please delete paragraph [0008] and substitute therefor the following:

A technology described in the Patent Publication number 2002-134287 changes the instantaneous value of power supplied to the lamp and also changes each wave form of voltage applied across the lamp or the lamp current into wave form except square wave. Therefore, a comparatively ~~complicate~~ complicated control is required.

Page 3, please delete line 9 in its entirety and substitute therefor the following:

~~DISCLOSURE OF THE INVENTION~~ SUMMARY OF THE INVENTION

Page 3, please delete paragraph [0009] and substitute therefor the following:

It is therefore an object of the present invention to keep the temperature of electrodes or within a bulb of a HID lamp in a proper state through simple control.

Pages 3 and 4, please delete paragraph [0011] and substitute therefor the following:

A discharge lamp ballast of the present invention comprises a power converter and a control circuit. The converter includes at least one switching element and is connected between a power source and ~~[[a]]~~ an HID lamp. After the start of the lamp, the control circuit controls an on/off state of the switching element so as to provide prescribed lamp power for the lamp based on lamp power control. According to one aspect of the invention, the control circuit controls the on/off state of the switching element so that at least one of an effective value and a peak value of the lamp power provided for the lamp is increased more than that adjusted by constant lamp power control based on high power control after the start of the lamp. The constant lamp power control is control for adjusting the effective value of the lamp power provided for the lamp to a prescribed power value. Thus, by controlling the on/off state of the switching element based on the high power control, it is possible to keep temperature of electrodes or within a bulb of the lamp in a proper state. As a result, since formation of a protrusion on the electrode can be

promoted and an arc origin point can be stabilized, flicker generation and electrode degradation are prevented and the life of the lamp can be extended.

Page 4, please delete paragraph [0012] and substitute therefor the following:

Preferably, the ballast comprises a state detection means that detects a state of the lamp, and the control circuit changes the lamp power control to the constant lamp power control or the high power control based on a detection result of the state detection means after the start of the lamp. In case of the constant lamp power control, the control circuit controls the on/off state of the switching element so as to adjust the effective value of the lamp power provided for the lamp to the prescribed power value. In case of the high power control, the control circuit controls the on/off state of the switching element so that at least one of the effective value and the peak value of the lamp power provided for the lamp is increased more than that of the constant lamp power control.

Page 6, please delete paragraph [0018] and substitute therefor the following:

After reaching a stable state of the lamp, control for the on/off state of the switching element based on the constant lamp power control and control for the on/off state of the switching element based on the high power control may be performed alternately and periodically through the control circuit. According to this control, even if there are different variations such as variation of ambient conditions, fluctuation of power voltage and so on during operation of the lamp, it becomes easy to maintain temperature of the electrodes or within the bulb of the lamp, and in consequence flicker generation and electrode degradation can be prevented.

Page 8, please delete paragraph [0025] and substitute therefor the following:

Preferably, the control circuit executes correction control or non-correction control as the high power control. In case of the correction control, the control circuit controls the on/off state of the switching element so that a part of lamp power provided for the lamp is increased more than that adjusted by the constant lamp power control while equalizing the effective value of the lamp power provided for the lamp with that adjusted by the constant lamp power control. In case of the non-correction control, the control circuit controls the on/off state of the switching element so that a part of lamp power provided for the lamp is increased more than that adjusted by the constant lamp power control. According to this control, it is possible to raise temperature of the electrodes of the lamp to keep the light output in a stable state.

Page 13, please delete paragraph [0034] and substitute therefor the following:

(FIRST EMBODIMENT)

FIG.1 shows a discharge lamp ballast 10 for ~~[[a]]~~ an HID lamp (e.g., extra-high-pressure mercury discharge lamp of 120-300 W) DL1. The ballast 10 comprises a resistor R11 for detecting an input current, a state detection circuit 12, a control circuit 13 and an igniter (not shown), and further comprises a power converter 11 connected between a DC power source DC1 with a positive terminal and a negative terminal and ~~[[a]]~~ an HID lamp DL1 with a first terminal and a second terminal. In order to start the lamp DL1, the igniter generates and applies high voltage to the lamp DL1.

Page 17, please delete paragraph [0048] and substitute therefor the following:

The control changeover function 130a is operable to change control for the lamp DL1 to lamp current control of the lamp current control function 130b at the start of the lamp DL1, and then change the lamp control to constant ~~lamp~~ power control of the constant power control function 130c at stabilization of the lamp DL1. The stabilization of the lamp DL1 is judged based on the detection result from the A/D converter 13a (the output voltage). Namely, lamp voltage immediately after the start of the lamp DL1 is low voltage, and therefore a start time period is set for a period of time that voltage across the resistor R13 is lower than reference voltage. The reference voltage is previously set based on voltage across the lamp DL1 in its stable operation. Accordingly, when the voltage across the resistor R13 reaches or exceeds the reference voltage, the lamp DL1 is judged to reach a stable state.

Pages 17 and 18, please delete paragraph [0049] and substitute therefor the following:

The control changeover function 130a is also operable to change lamp power control to constant ~~lamp~~ power control or high power control based on the detection result from the A/D converter 13a (lamp voltage) after stabilization of the lamp DL1. A detailed explanation of this is given later.

Pages 18 and 19, please delete paragraph [0051] and substitute therefor the following:

The constant power control function 130c is operable to supply correction quantity on output (lamp) power for the constant lamp power control to the PWM control circuit 131 according to the changeover control of the control changeover function 130a. The correction quantity is to adjust an effective value of lamp power provided for the lamp DL1 to a prescribed power value (rated power value or dimming power value). In the operation, the correction quantity is calculated based on the detection result from the A/D converter 13a (the output voltage) and a table for the constant lamp power control. In the table for the constant lamp power control, each detection result from the converter 13a (output voltage value) is previously related to an output (lamp) power control value. Accordingly, the function 130c converts the detection result into an output power control value by reading out the output power control value corresponding to the detection result from the table for the constant lamp power control, and finds difference between the output power control value and the output (lamp) power target value, as the correction quantity on output power. This constant lamp power control is generally changed in order to stably keep lamp power of the lamp DL1 during steady operation after the lamp current control of the lamp current control function 130b.

Page 19, please delete paragraph [0052] and substitute therefor the following:

The high power control function 130d is operable to supply correction quantity on output power for the high lamp power control to the PWM control circuit 131 according to the changeover control of the control changeover function 130a. The correction quantity is to increase at least one of an effective value and a peak value of the lamp power provided for the lamp DL1 more than that adjusted with the constant power control function 130c. In the operation, the correction quantity is calculated based on the detection result from the A/D converter 13a (the output voltage) and a table for the high lamp power control.

Pages 20 and 21, please delete paragraph [0056] and substitute therefor the following:

The above control changeover function 130a is further explained. In case of the HID lamp DL1, visible lamp flicker occurs when temperature of electrodes and within a bulb thereof falls. On account of this, as shown in FIG. 3, after stabilization of the lamp DL1, the function 130a changes lamp power control to the high power control when the lamp voltage (voltage across R13) reaches or exceeds threshold voltage V_{t1} that is higher than the rated lamp voltage V_{RL1} , and changes lamp power control to the constant lamp power control when the lamp voltage is

less than the threshold voltage V_{t1} . The threshold voltage V_{t1} for the rated operation may be the same as or different from that for the dimming operation. In FIGS. 2 and 3, VR_{CC1} represents a voltage range in the start time period, and VR_{PC1} represents a voltage range utilized after the start time period of the lamp DL1 and this range is set so as to include the voltage V_{RL1} at intermediate portion thereof.

Page 21, please delete paragraph [0058] and substitute therefor the following:

Subsequently, when the lamp DL1 reaches a stable state, the lamp current control is changed to the constant lamp power control.

Page 21, please delete paragraph [0059] and substitute therefor the following:

Then, when temperature of the electrodes or within the bulb of the lamp DL1 falls owing to decrease of the lamp current and the lamp voltage reaches and exceeds the threshold voltage V_{t1} , the constant lamp power control is changed to the high lamp power control.

Pages 21 and 22, please delete paragraph [0060] and substitute therefor the following:

Thus, by changing the constant lamp power control to the high lamp power control when temperature of the electrodes or within the bulb of the lamp DL1 falls, the ballast 10 according to the first embodiment of the invention is able to prevent decrease of temperature of the electrodes or within the bulb.

Page 26, please delete paragraph [0073] and substitute therefor the following:

In case that the flicker detection function detects flicker generation, the control changeover function 230a changes lamp power control to the high power control for a prescribed time period through the timer function, and changes lamp power control to the constant lamp power control after the prescribed time period is passed.

Page 26, please delete paragraph [0074] and substitute therefor the following:

The operation of the ballast 20 is now explained. When the lamp DL2 starts in response to high voltage of the igniter, control for the lamp DL2 is changed to the lamp current control. When the

lamp DL2 then reaches a stable state, the lamp current control is changed to the constant lamp power control.

Page 26, please delete paragraph [0075] and substitute therefor the following:

Afterward, in case that temperature of the electrodes or within the bulb of the lamp DL2 falls in response to decrease of the lamp current and flick generation is detected, the constant lamp power control is changed to high lamp power control for the prescribed time period.

Pages 26 and 27, please delete paragraph [0076] and substitute therefor the following:

Thus, the ballast 20 according to the second embodiment of the invention changes the constant lamp power control to the high lamp power control based on detection of flick generation, and therefore it is possible to prevent decrease of the temperature of the electrodes or within the bulb. Also, since the decrease of the temperature of the electrodes or within the bulb causes visible flicker, the flicker generation can be prevented. Even if flicker immediately stops after the constant lamp power control is changed to the high lamp power control, the high lamp power control is continued for the prescribed time period, so that the temperature of the electrodes or within the bulb can be raised sufficiently. Inversely, if flicker does not stop during the prescribed time period, the high lamp power control is changed to the constant lamp power control, and therefore it is possible to prevent useless power consumption occurred by increasing power over needlessly long hours. In case that the ballast 20 is utilized for lighting, the lighting that gives little flicker and does not bring discomfort is possible. In case that the ballast 20 is utilized for a projector such as a liquid crystal projector or the like, even if its light source is a light source that is approximate to a point source, it is possible to obtain a stable light output with little flicker.

Page 27, please delete paragraph [0077] and substitute therefor the following:

In an alternate embodiment, the control changeover function 230a changes lamp power control to the high power control in case that the flicker detection function detects flicker generation, and changes lamp power control to the constant lamp power control in case that flicker generation is not detected. This changeover control can be added to the second embodiment, and any control can be selected.

Page 30, please delete paragraph [0086] and substitute therefor the following:

The non-correction control function 330H is operable to control the on/off state of the switching element Q31 so that a part of lamp power provided for the lamp DL3 is increased more than that adjusted by the constant lamp power control of the constant power control function 330c.

Pages 30 and 31, please delete paragraph [0087] and substitute therefor the following:

In examples of FIGS. 15, 16 and 17(a), according to the procedure of step S32 and S34-S35, the function 330H provides the integration circuit 333 with a pulse signal I_{DLup} for power increase in order to increase the peak value (wave height value) of part of the lamp current I_{DL} , and thereby increases the effective value of the lamp current I_{DL} . The signal I_{DLup} is provided m-times to the circuit 333 while the number of half-period pulses of output voltage of the inverter 313 reaches a specified number of times n, where m and n are integers. In FIG. 17(a), m and n are set to 1 and 5, respectively. In this non-correction control, the control in the period of time that the signal I_{DLup} is not provided is the same as the constant lamp power control, and therefore the effective value of the lamp current I_{DL} increases in response to the period of time that the signal I_{DLup} is provided. However, not limited to the setting, as shown in FIG. 17(b), the function 330H may provide two times (first and third half-periods) the signal I_{DLup} for the circuit 333 while the number of half-period pulses reaches 5. Thus, by setting n to an odd number, the effective value of the positive and negative lamp current I_{DL} can be increased, and it is possible to make electrodes of the lamp DL3 substantially equal in degradation. Also, as shown in FIG. 17(c), the function 330H may provide once the signal I_{DLup} for the circuit 333 while the number of half-period pulses reaches 6. Thus, by setting n to an even number, temperature of one electrode rises solely, and therefore in case that there is bias in temperature distribution of the electrodes, it is possible to raise temperature of the electrode with lower temperature, so that uneven in temperature distribution can be removed.

Page 31, please delete paragraph [0088] and substitute therefor the following:

The correction control function 330E is operable to control the on/off state of the switching element Q31 so that a part of lamp power provided for the lamp DL3 is increased more than that adjusted by the constant lamp power control of the function 330c while equalizing the

effective value of the lamp power provided for the lamp DL3 with that adjusted by the constant lamp power control.

Pages 31 and 32, please delete paragraph [0089] and substitute therefor the following:

In examples of FIGS. 15, 16 and 18(a), according to the procedure of step S33 and S34-S35, the function 330E provides the integration circuit 333 with a pulse signal I_{DLup} for power increase while providing the circuit 333 with a Vref adjustment signal for adjusting the level of DC voltage Vref applied to the PWM control circuit 331 from the circuit 333. In FIG. 18(a), the signal I_{DLup} is provided for the circuit 333 and thereby the effective value of the lamp current I_{DL} is increased as well, but by providing the Vref adjustment signal for the circuit 333, wave height values of the lamp current I_{DL} in the whole period of time are decreased in response to increment of the effective value of the lamp current I_{DL} by the signal I_{DLup} . As a result, the effective value of lamp power becomes equal to that adjusted by the constant lamp power control. Thus, even if the effective value of lamp power is not increased, it is possible to raise temperature of the electrodes and within the bulb of the lamp DL3 by causing a part of lamp power provided for the lamp DL3 to be larger than that adjusted by the constant lamp power control. Also, at changeover between the constant lamp power control and the correction control, the effective value of lamp power is not changed, and therefore variation of the light output of the lamp DL3 can be prevented. FIGS. 18(a) and 18(b) correspond to FIGS. 17(a) and 17(b), respectively. In another example, as shown in FIG. 18(c), the function 330E may provide twice (first and fifth periods) the signal I_{DLup} for the circuit 333 while the number of half-period pulses reaches 7. Thus, by providing the signal I_{DLup} for the circuit 333, variance of duration for increase of the lamp current is possible. Moreover, as shown in FIG. 19(a)-19(c), the parameter n for the signal I_{DLup} may be set to an even number. In FIG. 19(a), m and n are set to 6 and 1, respectively. In FIG. 19(b), m and n are set to 6 and 2, respectively. In FIG. 19(c), m and n are 6 and 1, respectively and the polarity of increased lamp current is inverse polarity as compared with FIG. 19(a).

Pages 32 and 33, please delete paragraph [0090] and substitute therefor the following paragraph:

In case that lamp power control is changed to the high power control, the control changeover function 330a is operable to change to control of the non-correction control function 330H or the

correction control function 330E based on various changeover conditions (S31 in FIG. 15). In the third embodiment, the function 330a changes lamp power control to the control of the function 330H based on a non-correction changeover condition, namely, in case that the lamp voltage reaches or exceeds a threshold voltage (cf. V_{t1} in FIG. 3). The function 330a also changes lamp power control to the control of the function 330E based on a correction changeover condition, namely, in case of a shift to dimming operation. However, not limited to this changeover control, in case that a state detection circuit and A/D converters are provided as well as in the same way as the second embodiment, the control changeover function may change lamp power control to the control of the non-correction control function when the light output detection circuit detects flicker generation. Also, the function may change lamp power control to the control of the correction control function when a change value in digital output from a voltage division circuit or a current detection circuit is equal to or larger than a prescribed value, or when shifting a dimming operation.

Pages 34 and 35, please delete paragraph [0094] and substitute therefor the following:

However, efficacy by increase of the lamp current I_{DL} in the high power control mutually relates to the time of half period and the increase rate of the current I_{DL} , and therefore it is necessary to decide the optimal value in consideration for characteristics of the lamp DL3. An experimental example is explained. A HID lamp DL3 was used and its rated lamp power was 150W. The frequency of output voltage of the inverter 313 was set to 170 Hz, and each power of 135 W, 140 W and 145W was provided to the lamp DL3. And the lamp DL3 was operated for one hour while keeping the peak value of the lamp current I_{DL} . Also, ~~as well as~~ like the non-correction control shown in FIG. 17, n and the increase rate were respectively 5 and 30 %, and the lamp DL13 was operated for one hour while increasing the peak value of the lamp current I_{DL} in a half period more than that in the other period of time while the number of half-period pulses of output voltage reached 5. In case that the peak value of the lamp current I_{DL} was kept to be constant, arc jumping occurred over a comparatively long time. The arc jumping means a phenomenon that end position of the arc is not stable and moves here and there, resulting change in the light output. On the contrary, in case of the non-correction control, arc jumping did not occur.

Pages 35 and 36, please delete paragraph [0096] and substitute therefor the following:

In an alternate embodiment, the micon 330 comprises only the correction control function 330E in the high power control function 330d. In this configuration, the control changeover function 330a changes lamp control to the lamp current control till the lamp voltage reaches voltage of the rated lower limit (see table 1 described later) of the rated lamp voltage after the start of the lamp DL3, and also changes lamp power control to the correction control or the constant lamp power control in case of rated operation and dimming operation. Concretely, the function 330a changes to the correction control of the function 330E when the lamp voltage is voltage within the rated range (see table 1 described later), and also changes to the constant lamp power control of the constant power control function 330c when the lamp voltage is voltage lower than the voltage of the rated lower limit. This control is suitable for projectors. For example, when temperature within a projector rises and lamp voltage drops to voltage lower than the voltage of the rated lower limit, lamp power control is changed from the correction control of the high power control to the constant lamp power control and therefore the temperature within the projector can be lowered.

Pages 36 and 37, please delete paragraph [0099] and substitute therefor the following:

The high power control function 430d is operable to control the on/off state of the switching element Q41 so that at least one of an effective value and a peak value of the lamp power provided for the lamp DL4 is increased more than that adjusted by constant lamp power control based on the first high power control. The function 430d is also operable to change frequent degree of increase of the lamp current through the lamp DL4 so that lamp power under the second high power control becomes larger than that under the first high power control based on the second high power control.

Page 42, please delete paragraph [0113] and substitute therefor the following:

As shown in (b) and (c) of FIG. 26, in the period of time that the light passes through the red region, the lamp current I_{DL} is increased more than that in any of the other period of times, but in a period of time that the light passes through one of the other regions, the lamp current may be increased more than that in another of the other period of times. In period of times corresponding to at least two regions, the lamp current may be also increased more than that in another of the other period of times. In (b) of FIG. 26, the effective value of the lamp current I_{DL} under the high power control (solid line) is set to a value larger than that under the constant

lamp power control (broken line). In (c) of FIG. 26, the effective value of the lamp current I_{DL} under the high power control (solid line) is set to a value equal to that under the constant lamp power control (broken line). A color filter without colorless region (W) can be replaced with the filter 14. But not limited to the projector of the fifth embodiment, each ballast of the above embodiments can be used for various projectors.